

Claims

- [c1] 1.A vibration control system for a rotary machine having a rotor, comprising:
a sensor disposed within the rotary machine for sensing vibration of the rotor;
a vibration damping device disposed within the rotary machine for imparting a reaction force to the rotor; and
a controller arranged in operable communication with said sensor and said vibration damping device, said controller adapted to receive a sensor signal from said sensor and to send a control signal to said vibration damping device for damping the vibration of the rotor.
- [c2] 2.The vibration control system of Claim 1, wherein:
said vibration damping device comprises a piezoelectric effect.
- [c3] 3.The vibration control system of Claim 1, wherein:
said vibration damping device comprises a piezoelectric actuator.
- [c4] 4.The vibration control system of Claim 3, wherein:
said piezoelectric actuator comprises a piezoelectric stack.
- [c5] 5.The vibration control system of Claim 3, wherein:
said piezoelectric actuator is made of a material selected from the group consisting of; lead-zirconate-titanate, lead-titanate, lead-zirconate, and barium-titanate.
- [c6] 6.The vibration control system of Claim 1, wherein:
said vibration damping device disposed within the rotary machine further imparts a trans-axial reaction force to the rotor that is counter to the vibration of the rotor.
- [c7] 7.The vibration control system of Claim 1, wherein:
said vibration damping device dampens the vibration of the rotor by at least 50-percent.
- [c8] 8.The vibration control system of Claim 3, wherein:
said controller comprises:
a signal amplifier for receiving the vibration sensor signal and conditioning the

signal;

an analog-to-digital converter for digitizing the conditioned signal;

a digital signal processor for further conditioning the digitized signal;

a control algorithm for calculating an output signal based on the input signal from said digital signal processor;

a digital-to-analog converter for converting the output signal into an analog response signal; and

a piezoelectric amplifier for conditioning the analog response signal.

[c9] 9.The vibration control system of Claim 1, further comprising:

an active vibration control system wherein said vibration damping device comprises an actuator having at least one gain constant.

[c10] 10.A rotary machine having a vibration control system for controlling vibrations resulting from an excitation force acting upon the rotary machine, comprising:

a rotor bearing housing;

at least one bearing supported within said rotor bearing housing;

a rotor rotatably disposed adjacent said at least one bearing;

at least one sensor disposed within the rotary machine to sense vibration of said rotor;

at least one vibration damping device disposed proximate said at least one bearing to dampen the vibration of said rotor; and

a controller arranged in operable communication with said at least one sensor and said at least one vibration damping device, said controller adapted to receive a sensor signal from said at least one sensor and to send a control signal to said at least one vibration damping device.

[c11] 11.The rotary machine of Claim 10, wherein:

said at least one vibration damping device comprises a piezoelectric effect.

[c12] 12.The rotary machine of Claim 10, wherein:

said at least one vibration damping device comprises a piezoelectric actuator.

[c13] 13.The rotary machine of Claim 12, wherein:

said piezoelectric actuator comprises a piezoelectric stack.

- [c14] 14.The rotary machine of Claim 12, wherein:
said piezoelectric actuator is made of a material selected from the group consisting of; lead-zirconate-titanate, lead-titanate, lead-zirconate, and barium-titanate.
- [c15] 15.The rotary machine of Claim 10, wherein:
said at least one bearing comprises at least one bearing pad and further comprising at least one bearing support pin disposed between said at least one vibration damping device and said at least one bearing pad.
- [c16] 16.The rotary machine of Claim 10, wherein:
said at least one bearing is selected from the group consisting of; bearing pad, tilting pad, journal bearing, roller bearing and ball bearing.
- [c17] 17.A method for damping the vibration of a rotor in a rotary machine,
comprising:
sensing the vibration of the rotor;
communicating the sensed rotor vibration to a vibration damping device; and
damping the vibration of the rotor.
- [c18] 18.The method of damping set forth in Claim 17, wherein said communicating the sensed rotor vibration to a vibration damping device, further comprises:
communicating the sensed rotor vibration to a piezoelectric actuator.
- [c19] 19.The method of damping set forth in Claim 18, wherein said communicating the sensed rotor vibration to a piezoelectric actuator, further comprises:
amplifying the vibration sensor signal;
converting the amplified signal from an analog signal to a digital signal;
processing the digital signal in preparation for analysis;
calculating a counter-vibration response signal from the processed signal;
converting the response signal from a digital signal to an analog signal; and
conditioning the analog signal for use by the piezoelectric actuator.
- [c20] 20.The method of damping set forth in Claim 19, wherein said damping the vibration of the rotor, further comprises:
applying the counter-vibration response signal to the piezoelectric actuator;

vibrating the piezoelectric actuator at a frequency similar to the rotor vibration frequency.

- [c21] 21.The method of damping set forth in Claim 20, wherein said vibrating the piezoelectric actuator, further comprises:
vibrating the piezoelectric actuator according to the equation
$$H(s) = X1(s) / F(s).$$
- [c22] 22.A vibration control system for a rotary machine having a rotor, comprising:
means for sensing vibration of the rotor;
means for calculating a counter-vibration response signal based on the sensed vibration of the rotor; and
means for generating a counter-vibration force based on the counter-vibration response signal for damping the vibration of the rotor.
- [c23] 23.The vibration control system of Claim 22, wherein said means for calculating a counter-vibration response signal further comprises:
means for calculating a transfer function in the frequency domain for providing an output to input signal ratio according to the equation
$$H(s) = X1(s) / F(s).$$